Winter, Thomas A. (1998 [2004]) 'Impact of the Northridge Earthquake on the Garnier Building, Los Encinos State Historic Park', in *Disaster Management Programs for Historic Sites*, eds Dirk H. R. Spennemann & David W. Look. San Francisco and Albury: Association for Preservation Technology (Western Chapter) and The Johnstone Centre, Charles Sturt University. Pp. 99-110.

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Impact of the Northridge Earthquake on the Garnier Building, Los Encinos State Historic Park

THOMAS A. WINTER [¶]

The subject project is an 1872 two-story stone structure in the San Fernando Valley of Los Angeles, California. The site is on Ventura Boulevard (old Highway 101): west of the 405 Freeway and about 5 miles (8 km) from the Northridge Earthquake epicenter. The property consists of a small site with a core of historic structures that constitute the prime resources of a historic park.

The Garnier Building in Los Encinos State Historic Park is a two-story building of rough limestone random ashlar and lime mortar construction. The walls are approximately 18 inches (45.7 cm) thick and are plastered on each side with a lime plaster approximately 1 inch (2.54 cm) thick. The building is 26.5 feet (7.95 m) by 45 feet (13.5 m) and approximately 23 feet (6.9 m) tall to the eaves walls; the gable end walls are over 30 feet (9 m) tall at the peak. There is a partial basement on the northern half of the building with a 6.5 feet (1.95 m) height to joists.

The structure was retrofitted with an earthquake bracing and tying scheme in 1989. This scheme installed 17 inch by 0.75 inch (43.2 cm) and diameter 1.9 cm steel anchors in epoxy grouted holes at 2 feet (61 cm) on center around the perimeter of both floors and the ceiling. A shear wall with footing was installed in a location approximately on the line of a historic wall between the first and second floor - which was approximately at the third point from the southern end of the structure. Diaphragms and chords were

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developed on each floor and the ceiling line. The high gable end walls were braces to the ceiling diaphragm.

The earthquake damaged the northern end (short) wall which was farthest from the shear wall. Severe cracking caused the corners to separate from the rest of the masonry and holes to develop at the panels between the windows on the first floor. The west side (long) wall was cracked at each panel between the windows. After the earthquake, immediate stabilization was done by installing a temporary shear and support wall near the damaged north wall. The masonry, restrained at the floor lines, remains in plane along with the majority of the wall surfaces which are intact.

Repair assumptions

There were several initial assumptions which are a part of the California State Park approach to dealing with a damaged historic structure:

- The buildings must be restored or 'fixed' with as little alteration as possible.
- The original fabric will be saved to the degree possible. This is tempered with the 'cost reality' that the higher the costs the less likely the repairs will be accomplished within a timely period and, in the case of re-occurring events such as earthquakes, the future reliability of the 'fix' in such events must be considered.
- There are archaeological resources in and around the structures that must be protected, avoided or mitigated.

The process

Since this was a federally declared disaster, a process was established to receive federal disaster aid funds to repair the damage. From the State Park's point of view the damage has closed a small park with a small total attendance and limited funds for repairs are not allocated to the park on an 'emergency' basis. Funds for the state match will need to be budgeted through the normal process, which involves putting them into the district maintenance budget to compete with other maintenance projects. Currently, only a small percentage of projects are funded from the lists of potential park maintenance projects.

The budgets for the maintenance projects are made up each Spring. The Federal Emergency Management Agency (FEMA) has provided US$4,500 for preliminary Architecture and Engineering which could be spent immediately, but the 10% match must be identified to the budget office before the funds can be encumbered. The FEMA money is reimbursable and state money must be spent first, then reimbursed. The California State Park Director has authorized spending the money, as long as the match is identified.

Staff time will be used as match, but the majority of the work is engineering in nature and the department has no structural engineers. That means that the engineering must be contracted so no match can be achieved towards construction.

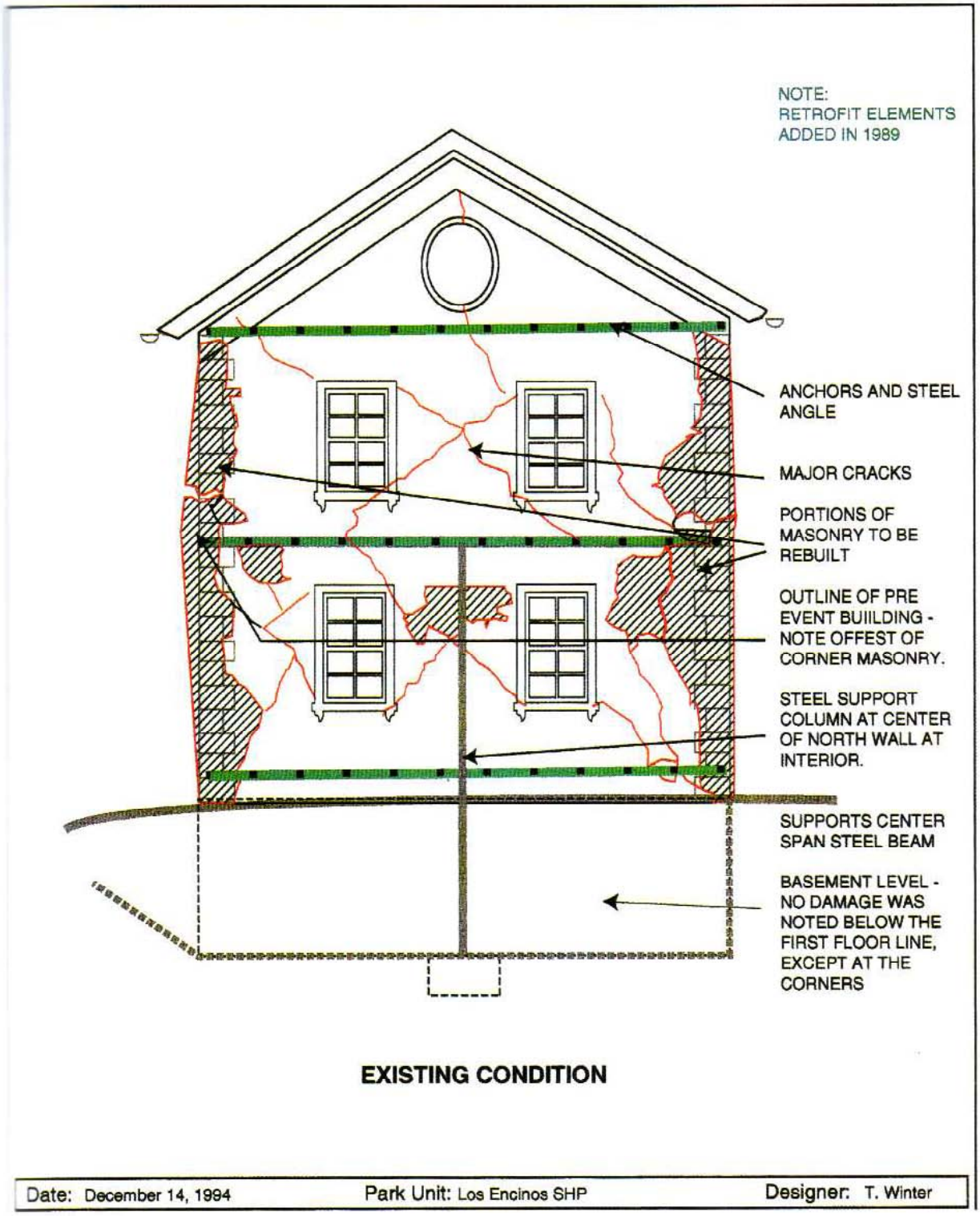

Figure 18.1 Garnier Building: north elevation. Existing condition following Loma Prieta, Dec. 1994. (Drawing: Thomas Winter 1994).

There were a total of five buildings damaged at this site by the 'quake. An overall estimate of the cost of repair is in the area of US$1 million dollars. The match is US$100,000 and that amount is a large portion of the district maintenance budget for one year. Because of the match requirement each step of the project, Preliminary Architect and Engineering, Architect and Engineering and Construction are taking a long time to realize - although without FEMA reimbursement these buildings might never be repaired.

Existing conditions

The retrofit performed as expected during the Northridge event. The walls were tied to the horizontal diaphragms and remain in plane at those locations. The retrofit did not keep the building from suffering significant damage, but life safety was maintained.

Damage to the structure was worst on the narrow, tall gable end walls, and the west side wall which has a row of six openings in each floor level creating a 'frame' structure situation. The east elevation, with fewer openings, was considerably stronger and acted as a diaphragm with punched openings.

The north elevation suffered severe cracking such that the area between the lower windows collapsed, leaving two small piers of masonry supporting the continuous header over the windows. The building corners, which had no anchors within the width of the wall, dislodged and are immanently in danger of collapse. The lack of corner anchors has been noted as a deficiency and current unreinforced masonry design includes corner anchors. The masonry above the second-floor windows remains in good condition with little cracking. This masonry was tied into the roof and second-floor ceiling structure during the retrofit.

The west elevation exhibits 'X' cracks at each 'pier' below the windows. There appears to be little, if any, amount of out-of-plane offset in the cracks, since this area is tied to the floor by anchors. The lower floor 'piers' area also cracked.

The south wall exhibits fewer diagonal cracks since it is protected by a shear wall located one third of the building length from the south wall. The cracks range from hairline to 0.5 inch (1.27 cm).

The doors and windows along three sides of the structure are operable, indicating little, if any, post-event racking of the masonry. The lower windows on the north elevation were damaged by the initial flexing or subsequent collapse of the masonry holding them.

Repairs and retrofit

Damage to the structure can be divided into three areas, based on the severity of the damage. Area one - the north wall; area two - the west wall; area three - the south and east walls.

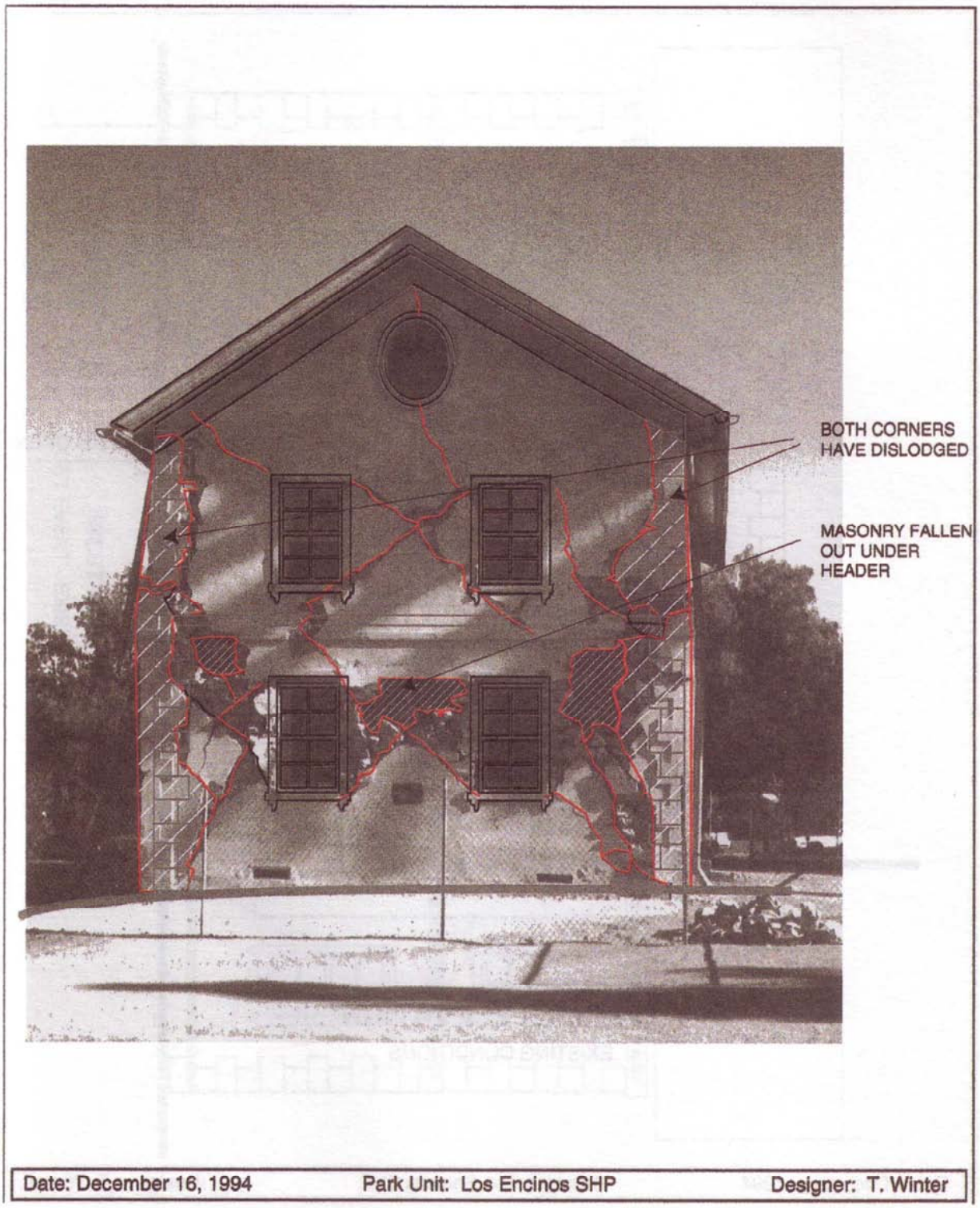

Figure 18.2 Garnier Building: north elevation. Existing condition following Loma Prieta, Dec. 1994. (Photo: Thomas Winter 1994).

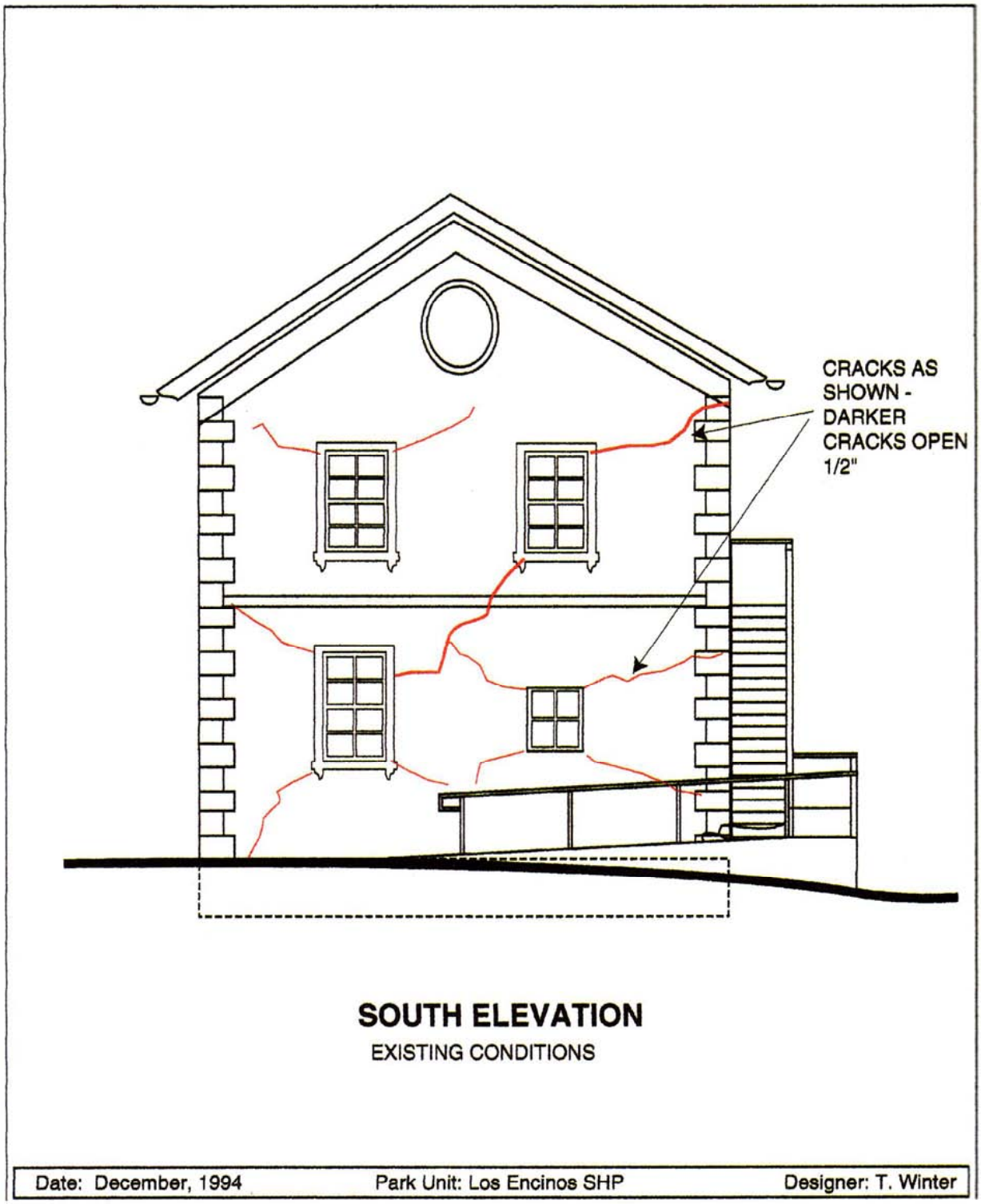

Figure 18.3 Garnier Building: south elevation. Existing condition following Loma Prieta, Dec. 1994. (Photo: Thomas Winter 1994).

Figure 18.4 Garnier Building: west elevation. Existing condition following Loma Prieta, Dec. 1994. (Photo: Thomas Winter 1994).

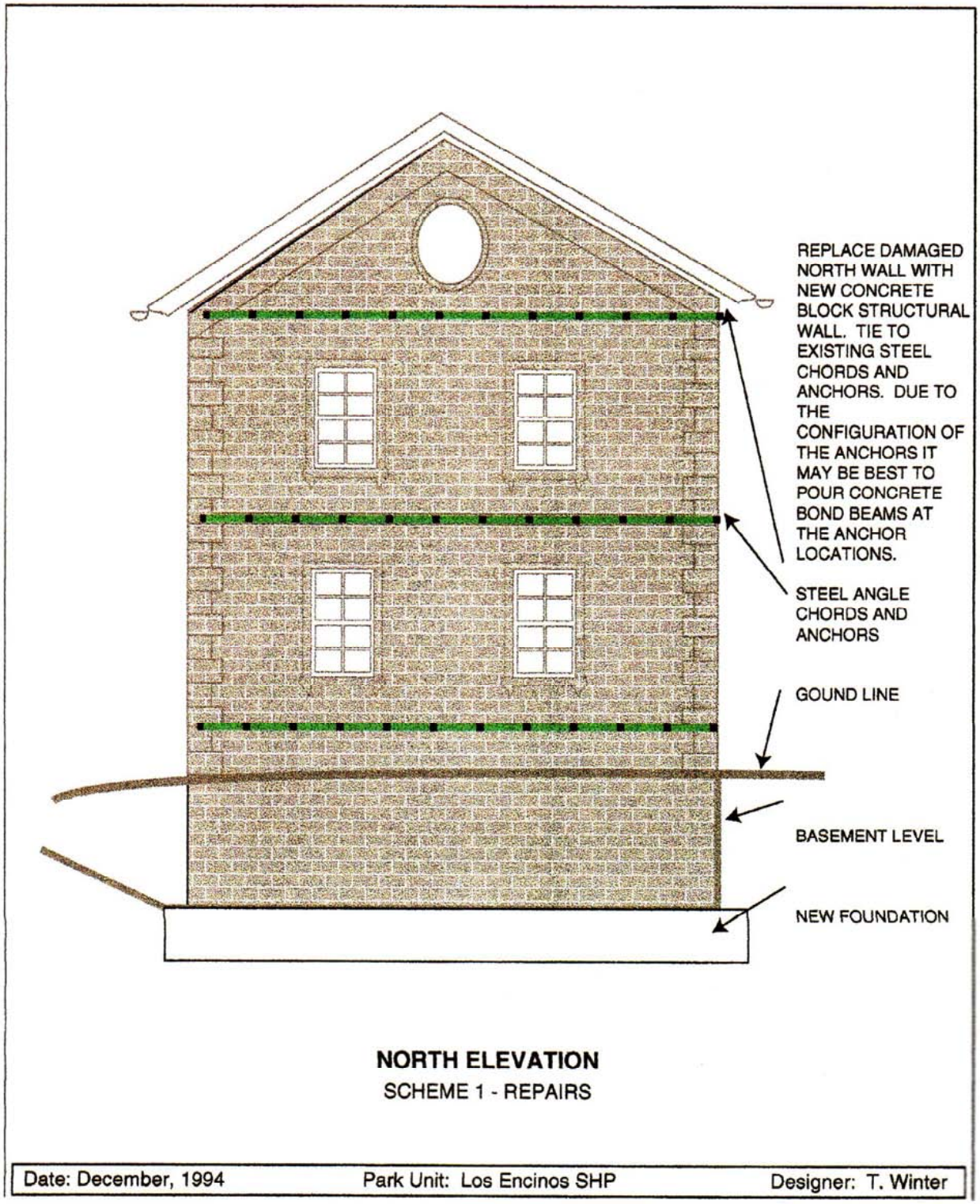

Figure 18.5 Garnier Building: north elevation. Mitigation Scheme One. (Drawing: Thomas Winter 1994).

During the retrofit process, nearly two hundred 1-inch (2.54 cm) holes were cored into the masonry to within 1 inch (2.54 cm) of the outside to insert the tie rods. The first holes were then 'filled' with epoxy before inserting the 0.75-inch (1.9 cm) anchor rods. Considerable epoxy was needed to fill the holes and it was determined that the wall contained a large amount of void space. The anchors were subsequently fitted with screens which lessened the amount of epoxy required.

The void space can now be used to strengthen the wall. Filling the voids with a relatively strong grout is possible since the limestone is quite hard. The new cracks can be filled with a similar grout. A grouting consultant is required to do a test panel on the building to determine the extent to which the wall will take grout, the spacing of the grout ports, and accurate cost data.

It is anticipated that all of the existing rock masonry will be treated as described above.

Area One: North wall

Three schemes have been analyzed for the most badly damaged wall. The three schemes have differing amounts of intervention but each attempts to arrive at a similar seismic resistance.

Scheme One

This removes all of the wall and replaces it with a new concrete block wall. This solution is simple but requires demolition of all of the original historic fabric of the wall. The thickness of the original masonry is about 18 inches (45.7 cm), the widest block is 12 inches (30.5 cm); either the wall must be furred to the proper thickness or the block could be set sideways to make a 16-inch (40.6-cm) wall and plastered to the appropriate thickness. The furring could be constructed of original masonry, but since there is no indication of the masonry underlying the plaster it is not cost effective. There are several variations of how the wall could be configured in the basement level, but scheme one costs are based on removing the existing masonry, excavating and installing a footing.

The masonry will be tied to the structure through the existing steel angle and new grout anchors, which can be cast into the block or into a bond beam poured at that level. The block/bond beam must be set flush with the black of the angle to assure shear transfer.

Due to the cost of demolition, excavation and reconstruction, this scheme is the most costly. It is also the most damaging to the historic fabric.

Scheme Two

This removes the most badly damaged portion of the wall and replaces it with a block, shotcrete or poured concrete shear wall. The damaged and offset corners can be demolished and rebuilt with matching masonry, or be formed and shot or poured back with a concrete mix. The remaining portion of the wall would need to be pressure grouted after the cracks, holes and other damage have been repaired. New anchors will be placed in the corners tied to the steel angles.

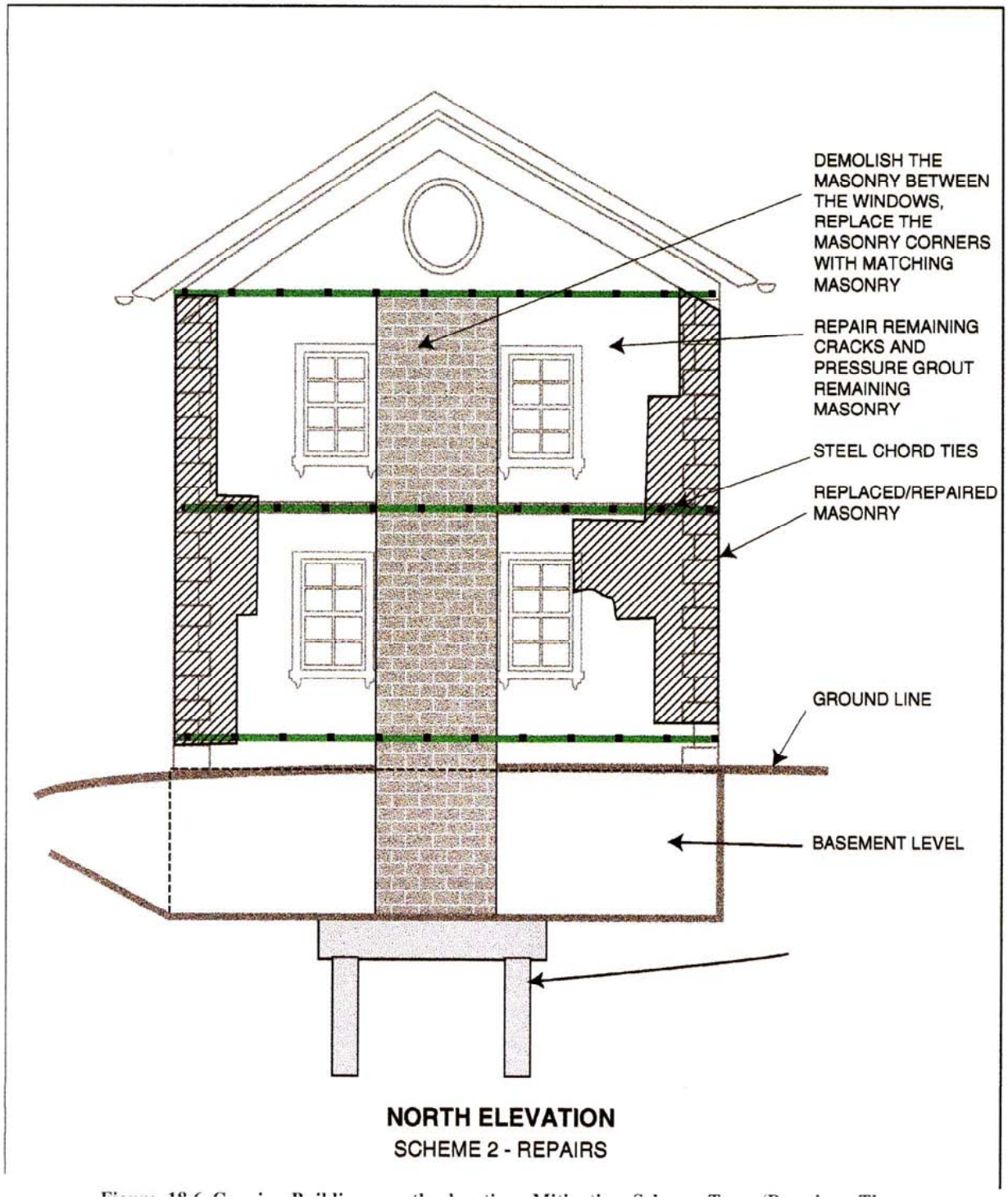

Figure 18.6 Garnier Building: north elevation. Mitigation Scheme Two. (Drawing: Thomas Winter 1994).

The shear wall must be constructed through the basement, and will require a footing and probably piles or piers to develop the lateral resistance required.

This scheme is the least costly and appears to be a viable alternative. Damage to the historic fabric is relatively minor and is perhaps the least. The ties between the angle chord and the new shear wall become very important and must be calculated to assure their adequacy.

This scheme requires that the site be excavated. The cost of archaeological monitoring and testing is not added into the cost estimate, but would be considerable.

Scheme Three
This requires the least demolition; only the displace corners would need to be removed and reconstructed. The holes will be built up of matching masonry. The foundation appears to have suffered little damage and can be reused.

To carry the seismic loads better, this wall will be upgraded. The plaster finishes will be removed from the top steel angle chord to the base of the wall and replaced with a reinforced 'structural plaster' which will be tied into the steel angle chords at each level. This scheme assumes that both inside and exterior faces will be treated and tied to each other by steel rods drilled at regular intervals. The plaster will be carried around the corners to tie into the anchors along the long walls. In addition, new corner anchors may be required to secure the corners which failed in this last event.

This scheme retains the most historic masonry but requires that significant amounts of plaster be removed to develop the required strength. The cost is very close to Scheme Two and is therefore a viable alternative.

Since this alternative requires no excavation, a problem in archaeological sensitive sites, it is the preferred alternative. The cost of archaeological monitoring and testing would make Scheme Two more costly.

Area Two: West wall
Only one scheme is proposed for this wall. The general treatment will be to pressure grout the wall and cracks. Some additional strength is required at the points which cracked severely. Structural plaster is proposed for the inside finish where shown on the drawing. This will be tied to the steel chords and into the rock with epoxy anchors at regular intervals.

Area Three: South and east walls
The general treatment should be sufficient to both repair and upgrade these walls to better lateral resistance. That will include pressure grouting the wall and the cracks.

Finishes, furnishings and exhibits

The building was recently rehabilitated as a visitors center. Repair/replacement of damaged finishes, doors and windows is the extent of the work required to bring the building back to its pre-event status. Some damage was done to the exhibits and furnishings, which need to be refinished or replaced as indicated.

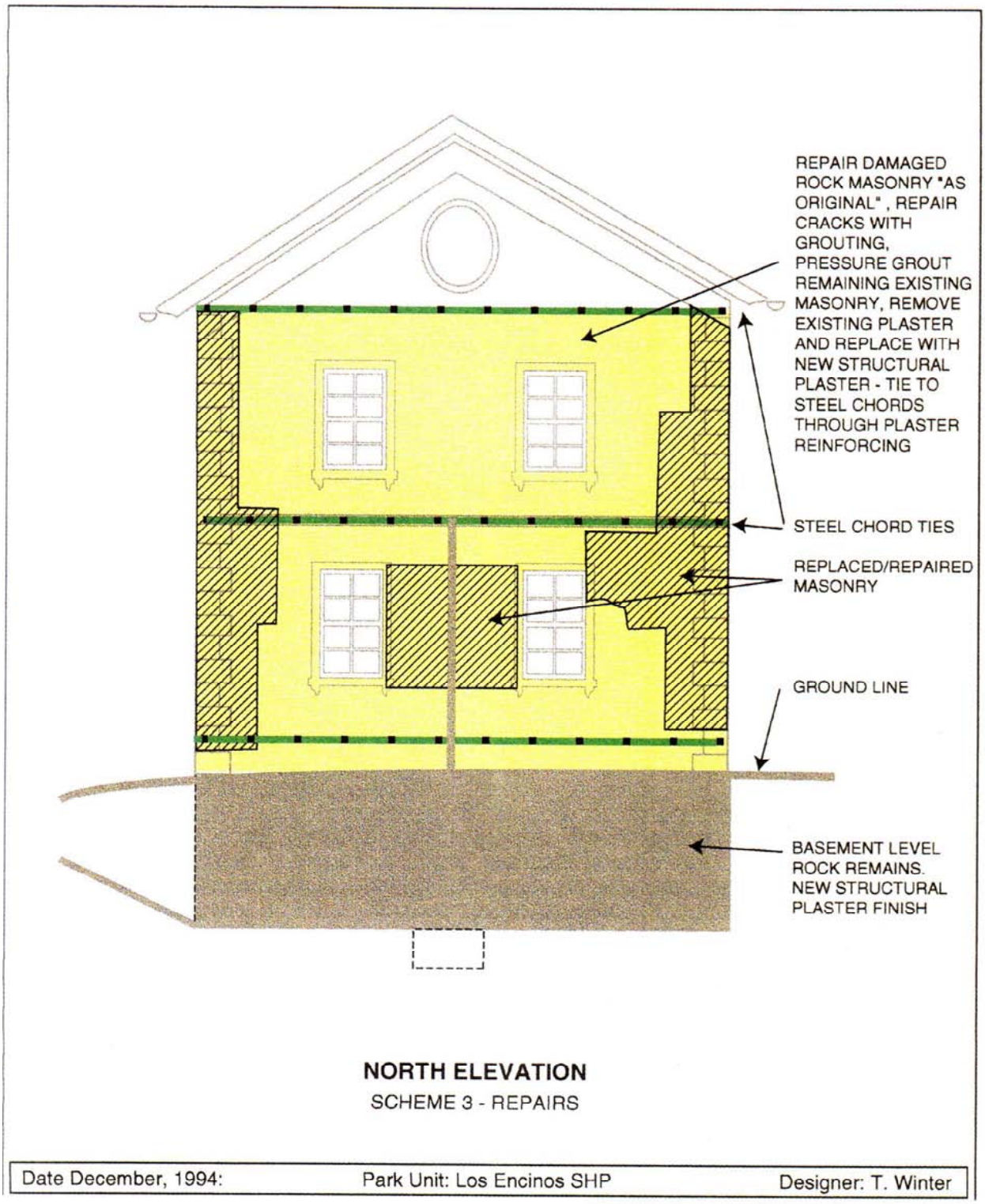

Figure 18.7 Garnier Building: north elevation. Mitigation Scheme Three. (Drawing: Thomas Winter 1994).